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Revision of the genus *Bdellamaris* (Hirudinea: Piscicolidae) including a new combination, *Bdellamaris manteri*

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Abstract The New Zealand fish leech genus *Bdellamaris* was revised and a redescription of the type species, *Bdellamaris eptatreti*, was made using material from *Eptatretus cirrhatus*, the type host for *B. eptatreti*. Since the holotype has been lost and paratypes exist only in the form of frontal sections of approximately one third of a leech, a neotype was designated. Individuals in *Bdellamaris* lack eyes, ocelli, and conducting tissue and possess 11 pairs of pulsatile vesicles, 6 pairs of testisacs, accessory gland cells on the terminal portion of the male reproductive system, and a seminal receptacle. *Bdellamaris eptatreti* is characterised by a uniformly unpigmented body and suckers yielding a white overall appearance. *Makarabdella manteri* is transferred to the genus *Bdellamaris* after study of the type specimen and new material collected from the Chatham Rise, New Zealand. This species is characterised by its small size and by orange transverse pigment bands.

Keywords *Bdellamaris eptatreti*; *Makarabdella manteri*; New Zealand; Chatham Rise; dark ghost shark; *Hydrolagus novaezealandiae*

INTRODUCTION

Piscicolid leeches, which are parasites on fish, are found worldwide in freshwater and marine environments (Sawyer 1986). Currently there are six species of piscicolid leeches known from the waters surrounding New Zealand: *Branchellion parkeri* Richardson, 1949, *Notobdella nototheniae* Benham, 1909, *Stibarobdella macrothela* (Schmarda, 1861), *Bdellamaris eptatreti* Richardson, 1953, *Makarabdella manteri* Richardson, 1959, and *Galatheaabdella bruuni* Richardson & Meyer, 1973 (Hewitt & Hine 1972; Richardson & Meyer 1973). Much of our knowledge of these species came from research by L. R. Richardson in the 1940s and 1950s.

Richardson (1947) provided a review of the leeches from New Zealand, in which he mentioned five leeches; *Branchellion rajae*, *N. nototheniae*, a species belonging to *Ichthyobdella*, a species belonging to *Platybdella*, and a pontobdellid. The species belonging to *Ichthyobdella* was collected from Cook Strait but subsequently Richardson (1953) changed the genus to *Pontobdella*, but still did not supply a species-level identification. The species belonging to the genus *Platybdella* was also collected from Cook Strait, but no further reference has been made to this leech. Richardson mentioned a pontobdellid leech that was reported by Benham in 1904 on a skate and later described it as *Pontobdella benhami* (Richardson 1950). Llewellyn (1966) later synonymised this species with the widely distributed species *S. macrothela*.

Branchellion rajae was the first marine leech reported from New Zealand waters. Richardson (1947) stated, "Parker reported the first leech, proposing in 1892 the name of *B. rajae* for a *Branchellion* from the ray. The species is still undescribed." The name is therefore a *nomen nudum*. Richardson (1949) provided a description under the name *Branchellion parkeri*. This species has been reported from *Raja* sp. and *Mustelus* sp. by Richardson (1949) and *Callorhynchus milii* Bory de Saint-Vincent, 1823 also by Richardson (1953).

Notobdella nototheniae was described from Snares Island, a subantarctic island off New Zealand (Benham 1909). This leech, belonging to the subfamily Platybdellinae, was reported from the fish *Notothenia microlepidota* Hutton, 1875. *Notobdella nototheniae* was suspected by Richardson (1947) to be a synonym of *Ichthyobdella tentaculata*, but this was later refuted (Richardson 1959). The synonymy of the two species was again made by Meyer & Burreson (1990).

Richardson (1953) described *Bdellamaris eptatreti* from the hagfish *Eptatretus cirrhatus* (Foster, 1801). Many specimens had no location data, except for one collection from Cape Campbell. Additional specimens were later reported from Milford Sound and the Tasman Sea (Richardson & Meyer 1973), the latter collected from the hagfish *Myxine* sp. No other species have been described in this genus and it has remained monotypic for the past five decades.

Makarabdella manteri was described from a single specimen found in the gill chamber of *Leptoscopus* sp. caught off Makara near Wellington (Richardson 1959). The leech was not attached to the gill chamber and therefore the host record was considered questionable.

Hewitt & Hine (1972) provided a list of all fish parasites found in New Zealand waters. They listed five species of piscicolid leech: *B. eptatreti*, *B. parkeri*, *M. manteri*, *N. nototheniae*, and *P. benhami*. No new host records were reported.

The final New Zealand piscicolid leech described to date is the monotypic *Galatheabdella bruuni*. This leech was collected in the Tasman Sea with *Coryphaenoides* sp. as the probable host (Richardson & Meyer 1973).

Specimens of the previously described *M. manteri* were collected from the dark ghost shark, *Hydrolagus novaezealandiae* (Fowler, 1911), on the Chatham Rise. These specimens allowed for a complete study of the internal anatomy of the species.

MATERIALS AND METHODS

Richardson (1953) states that the holotype of *B. eptatreti* was placed in the collection of the Department of Zoology, Victoria University College, Wellington, New Zealand. This specimen could not be located for observation and is presumed to be lost. However, specimens of *B. eptatreti* were examined from the collection of the Museum of New Zealand Te Papa Tongarewa, Wellington. The leeches were collected from the type host, *Eptatretus*

cirrhatus, on 27 June 1972 off the new wharf in Kaikoura, New Zealand. Two specimens were serial sectioned transversely at 6 µm thickness and stained with haematoxylin and eosin. Slides from the Museum of New Zealand Te Papa Tongarewa, Wellington, which were labeled by Richardson as *B. eptatreti* cotypes, were also examined. These slides contain serial sections of the clitellar (ZW.1366) and testicular (ZW.1367) regions.

Specimens of the previously described leech *M. manteri* were collected from the Chatham Rise aboard the National Institute of Water and Atmospheric Research (NIWA) research vessel *Tangaroa* during the annual hoki stock assessment cruises in 2004 and 2005. Fish were collected using a bottom trawl with a 58 m ground rope. Leeches were removed from the host and held in ambient sea water at 5°C for 5–7 days to allow them to partially digest the blood meal before fixation. Specimens were fixed in 95% ethanol (for future DNA extraction), 10% neutral buffered formalin, or Bouin's fixative. Two specimens fixed in Bouin's fluid were serial sectioned transversely at 6 µm thickness and stained with haematoxylin and eosin. The holotype specimen of *M. manteri* from the Museum of New Zealand Te Papa Tongarewa was also examined. This specimen was deposited as 12 slides of longitudinal sections. Thickness of sections is not known.

SYSTEMATICS

**Genus *Bdellamaris* Richardson, 1953
(=*Makarabdella* Richardson, 1959)**

Type species

Bdellamaris eptatreti Richardson, 1953

Diagnosis (emended)

Body not divided into distinct trachelosome and urosome. Eleven pairs of pulsatile vesicles. Tubercles and papillae absent. Twelve or more annuli per segment. No eyes, caudal ocelli, or segmental ocelli. Six pairs of testisacs. Accessory gland cells present on terminal portion of male reproductive system. Conducting tissue absent. Common oviduct opening into a seminal receptacle. Postceca present with fenestrae.

Bdellamaris eptatreti Richardson, 1953**Material examined****Neotype**

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.1532.

Host: hagfish (*Eptatretus cirrhatus*).

Locality/collection date: off new wharf, Kaikoura, 27 June 1972.

Collected by: I. Mannerling.

Paratypes

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.1366, serial sections.

Host: hagfish (*Eptatretus cirrhatus*).

Locality/collection date: unknown.

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.1367, serial sections.

Host: hagfish (*Eptatretus cirrhatus*).

Locality/collection date: unknown.

Voucher specimens

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.1407.

Host: hagfish (*Eptatretus cirrhatus*).

Locality/collection date: off new wharf, Kaikoura, 27 June 1972.

Collected by: I. Mannerling.

Diagnosis (emended)

Length up to 35.0 mm. Twelve annuli per segment. No pigmentation.

Description (emended)

External Length up to 35.0 mm. Body indistinctly divided into trachelosome and urosome. Twelve annuli per urosomal segment. Body and suckers lacking pigmentation, appearing uniformly white. Oral sucker eccentrically attached, without eyes, diameter up to 2 mm. Caudal sucker large, diameter up to 6 mm, subterminal.

Digestive system Mouthpore located in center of oral sucker. Mycetomes connect to oesophagus at XI and extend anteriorly to IX. Crop expands segmentally between testisacs. Intestine with anteriorly directed diverticula. Postceca present with fenestrae. Number of fenestrae could not be determined.

Coelomic system Eleven pairs of pulsatile vesicles. Lateral, dorsal, ventral, and testicular sinuses present. Both thin- and thick-walled lateral sinuses present. Dorsal, ventral, and lateral sinuses

connect at the urosome ganglia. Anterior portion of pulsatile vesicle connects to the thin-walled lateral canal. Posterior portion of pulsatile vesicle connects to the thick-walled lateral canal. Intersegmental connections between the thin-walled lateral canal and the testicular sinus.

Reproductive system Six pairs of testisacs intersegmentally from XIII/XIV to XVIII/XIX. Epididymus small and tightly coiled, located in XII/XIII. Vasa deferentia enlarge to ejaculatory ducts at the level of the male gonopore. Ejaculatory ducts continue anteriorly then turn ventrally. Ejaculatory ducts enter atrial cornua at ganglion X. Atrial cornua covered in thick mass of accessory gland cells. Atrial cornua fuse shortly after ganglion XI to become a common atrium. Common atrium large and opens into small bursa, which opens through the male gonopore. Accessory gland cells extend off the posterior portions of atrium and bursa in two distinct lateral appendages. Gland cells end before seminal receptacle, which is located between XII and XIII. Small common oviduct emerges from top of seminal receptacle, bifurcating into paired oviducts that shortly enter paired ovisacs. Ovisacs extend posteriorly to XIV/XV. No conducting tissue present.

Remarks

The genus *Bdellamaris* is in need of revision because of an error made by the original author in which postceca were said to be absent (Richardson 1953). Specimens collected from the type host, *Eptatretus cirrhatus*, which matched the species description in all other respects, were shown to have postceca with fenestrae. The description is also emended to allow greater variation in the annulation number. Annulation can be variable among species in the same genus as shown by the description of two species in the genus *Piscicola*, one with 4 annuli per segment and the other with 14 annuli per segment (Bielecki 1997). Information about the reproductive and coelomic systems is added, as these features are vital to current leech taxonomy. A seminal receptacle is noted in this genus for the first time.

Bdellamaris manteri (Richardson, 1959)
n. comb.

(=*Makarabdella manteri* Richardson, 1959)

(Fig. 1–4)

Fig. 1 *Bdellamaris manteri* n. comb. **A**, External morphology. **B**, Reconstruction of reproductive and digestive systems. (A, atrium; C, crop; F, fenestrae; G, ganglion XII; I, intestine; M, mycetomes; OS, ovisac; PC, postceca; S, spermatheca; T, testisac.)

Material examined

Holotype

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.220.

Host: monkfish, *Leptoscopus* sp.

Locality: Makara, New Zealand.

Voucher specimens

Museum of New Zealand Te Papa Tongarewa, Wellington ZW.1531.

Host: dark ghost shark, *Hydrolagus novaezealandiae*
Locality/collection date: Chatham Rise, New Zealand, 43°12.38'S, 177°41.75'E, 300 m, 22 January 2004.

Site of infection: mouth.

USNM 1081586:

Host: dark ghost shark, *Hydrolagus novaezealandiae*
Locality/collection dates: Chatham Rise, New Zealand, 43°21.56'S, 178°32.13'E, 380 m; 44°05.75'S, 175°52.31'E, 345 m; 43°03.79'S, 177°21.76'E, 298 m; 14 January 2005 to 21 January 2005.

Site of infection: mouth.

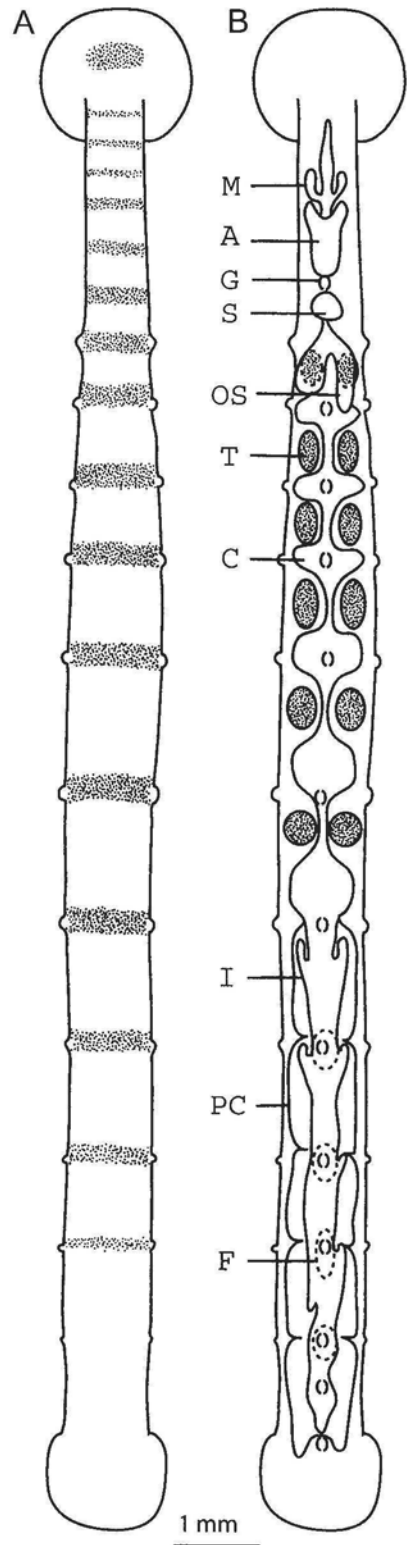
Diagnosis (emended)

Length up to 14.0 mm. Fourteen annuli per segment. Transverse orange pigment bands on trachelosome and urosome.

Description (emended)

External (Fig. 1A) Length up to 14.0 mm, width up to 0.9 mm at widest part of urosome. Body indistinctly divided into trachelosome and urosome. Pulsatile vesicles visible externally on larger specimens. Oral sucker relatively large (up to 1.0 mm) and eccentrically attached (Fig. 2A). Caudal sucker relatively small (up to 1.0 mm) and subterminal (Fig. 2B). Six transverse orange pigment bands on trachelosome. Ten transverse orange pigment bands on the urosome, incorporating the pulsatile vesicles and becoming faint posteriorly. Bands are composed of orange pigment flecks. No eyes, caudal ocelli, or segmental ocelli.

Digestive system (Fig. 1B) Mouthpore centrally located. Mycetomes attach to oesophagus at ganglion XI. Crop with a single caecum per segment.



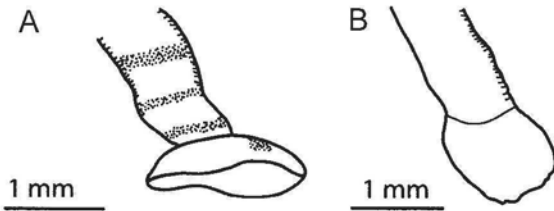


Fig. 2 *Bdellamaris manteri* n. comb. A, Oral sucker, lateral view. B, Caudal sucker, lateral view.

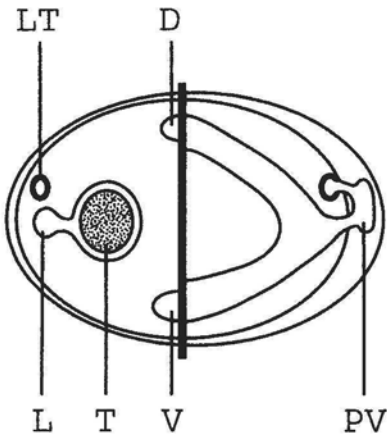
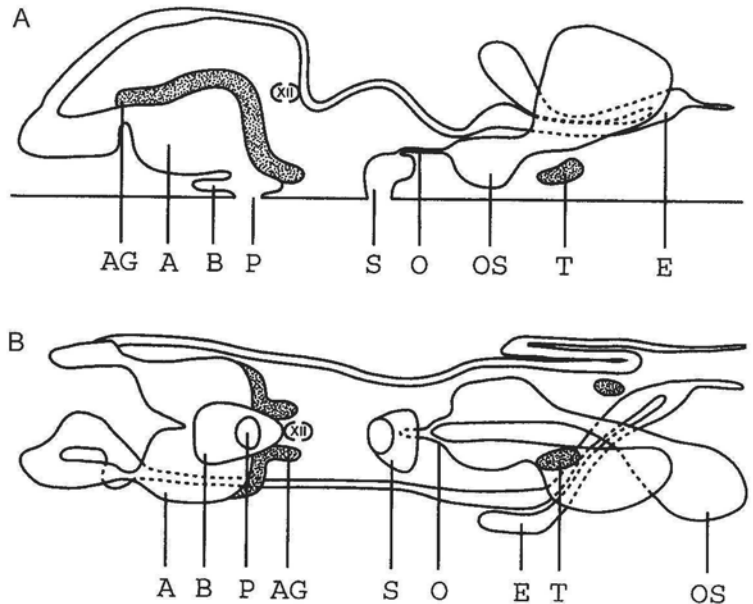


Fig. 3 *Bdellamaris manteri* n. comb. Diagrammatic view of coelomic system, left side intersegmental, right side segmental. (D, dorsal sinus; L, thin walled lateral sinus; LT, thick walled lateral sinus; PV, pulsatile vesicle; T, testisac; V, ventral sinus.)

Fig. 4 *Bdellamaris manteri* n. comb. A, Terminal portions of reproductive systems, lateral view. B, Terminal portions of reproductive systems, ventral view. (A, atrium; AG, accessory gland cells; B, bursa; E, epididymus; O, oviduct; OS, ovisac; P, male gonopore; S, spermatheca; T, testisac.)



Intestine begins intersegmentally at XIX/XX. Postcaeca present with four fenestrae.

Coelomic system (Fig. 3) Eleven pairs of pulsatile vesicles. Lateral, dorsal, ventral, and testicular sinuses present. Both thin- and thick-walled lateral sinuses present. Dorsal, ventral, and lateral sinuses connect at the ganglia. Anterior portion of pulsatile vesicle connects to the thin-walled lateral canal. Posterior portion of pulsatile vesicle connects to the thick-walled lateral canal. Intersegmental connections between the thin-walled lateral canal and the testicular sinus.

Reproductive system (Fig. 1B, 4A,B) Six pairs of testisacs intersegmentally from XIII/XIV to XVIII/XIX. First pair of testisacs very small and ventral to ovisacs. Epididymus of moderate size and tightly coiled, located in XII/XIII. Vasa deferentia enlarge to ejaculatory ducts at the level of the male gonopore. Ejaculatory ducts continue anteriorly then turn ventrally. Ejaculatory ducts enter atrial cornua at ganglion XI and are covered in a thick mass of accessory gland cells. Atrial cornua fuse shortly after ganglion XI to become a common atrium. Common atrium large and opens into small bursa, which opens through the male gonopore. Accessory gland cells extend off the posterior portion of the atrium and bursa in two distinct lateral appendages. Gland cells end before the seminal receptacle, which is located between XII and XIII. Small common oviduct emerges from top of seminal receptacle, bifurcating

into paired oviducts that enter paired ovisacs anterior to XIII. Ovisacs extend posteriorly to ganglion XIV. Masses of sperm present in ovisacs. No conducting tissue present.

Biology Leeches were removed from both the mouth and the ventral surface of the head of the host, although most were collected in the mouth, on the tongue. Leeches, although small, were very obvious because of the bright red colour from recent blood-feeding activity. When placed in a container with water, they proved to be weak swimmers. Individuals stayed alive for over a week before fixation. No mating or cocoon deposition was observed during this time.

Remarks

Specimens that were thought to belong to a new species of *Bdellamaris* were collected and studied. However, owing to the similarity to the external drawings and locality of *M. manteri* from the original description (Richardson 1959), the type specimen of this species was also studied. The original description of *M. manteri* placed it in a new genus, *Makarabdella*; however, a few of the major details were incorrect. Richardson (1959) described the new genus and species as having five pairs of testisacs and failed to mention a seminal receptacle located at the female gonopore. The first pair of testisacs is very small and lies ventral to the ovisacs. They could be easily overlooked in the longitudinal sections that were prepared by Richardson (1959). The presence of the seminal receptacle, which is not as easily overlooked, may have been hard to determine from the longitudinal sections. In the original description, this structure was described as a thin-walled atrium with little information on the arrangement of the oviducts relative to the structure. Examination of the holotype longitudinal sections of *M. manteri* revealed the presence of six pairs of testisacs and of a seminal receptacle. The information from the newly collected specimens allowed for a complete study of *M. manteri* and resulted in the transfer of *M. manteri* to the genus *Bdellamaris*, rendering *Makarabdella* a junior synonym.

Makarabdella manteri can be transferred to the genus *Bdellamaris* because of the presence of extensive accessory gland cells, a seminal receptacle, 11 pairs of pulsatile vesicles, six pairs of testisacs, the absence of eyes and ocelli, and the high annulation number. No other genus in the family Piscicolidae has this combination of characters. The genus *Makarabdella* was erroneously placed in the subfamily Platybdellinae by both Sawyer (1986) and

Epshtein et al. (1994), suggesting that pulsatile vesicles are not present. Richardson (1959) stated that there are external thin-walled vesicles that connected through the muscular envelope. However, he did say that muscle fibers were not seen and the vesicles may not be pulsatile. For this reason Sawyer (1986) placed *Makarabdella* in the subfamily Platybdellinae and included "subepidermal vesicles, small and apparently non-pulsatile" as part of the genus description. Epshtein et al. (1994) followed Sawyer without comment. The newly collected material documents that vesicles, although externally small, are present and are the typical pulsatile vesicles seen in leeches in the subfamily Piscicolinae.

Bdellamaris manteri is internally similar to *B. eptatreti*, but differs in host preference and external features. Both species exhibit unusual host preferences. *Bdellamaris eptatreti* has been found exclusively on hagfish, *Eptatretus cirrhatius* and *Myxine* sp. (Richardson 1953; Richardson & Meyer 1973), and is the only species of fish leech to be reported from hagfish. *Bdellamaris manteri* was originally described from monkfish, *Leptoscopus* sp., caught off Makara near Wellington (Richardson 1959). The host record is questionable because the leech was found in the gill chamber of the host but not attached to it (Richardson 1959). Specimens of *B. manteri* were also found attached to the dark ghost shark, *Hydrolagus novaezealandiae*, and this is only the second genus of fish leech to be reported from chimaerid fish. Szidat (1972) described *Branchellion callorhynchus* Szidat, 1972 from the elephantfish, *Callorhynchus callorhynchus* Meuschen, 1778, and also reported *C. callorhynchus* as an accidental host for a juvenile specimen of *Branchellion lobata* Moore, 1951. Another *Branchellion* species, *B. parkeri*, has been reported from the ghost shark *C. milii* (Richardson 1953).

There are two obvious external distinctions that can be made between the two *Bdellamaris* species. *Bdellamaris manteri* is a small leech, with the largest specimen 14.0 mm long, and has extensive pigmentation displayed as a series of transverse banding. *Bdellamaris eptatreti* can reach a length of 35.0 mm and live specimens observed by Richardson (1953) are uniformly unpigmented and appear white.

DISCUSSION

The seminal receptacle found in both *B. eptatreti* and *B. manteri* is similar to the seminal receptacle seen in *Notobdella nototheniae* as described by Meyer & Burreson (1983). The difference is the location

where the common oviduct opens into the receptacle, which is on the anterior surface in *Notobdella* and on the dorsal surface in *Bdellamaris*. Other features that distinguish *Notobdella* from *Bdellamaris* are the presence of five pairs of testisacs, eyes, segmental ocelli, and caudal ocelli (Meyer & Bureson 1983).

Bdellamaris eptatreti and *B. manteri* show similarities to *Trachelobdella*. Both genera have accessory gland cells that form bilateral appendages (Sawyer 1986) and conducting tissue is absent in both. However, *Trachelobdella* has far fewer annuli than *Bdellamaris* with only 3–6 annuli per segment. Sawyer (1986) stated that *Trachelobdella* has a true vagina with thick muscular walls and this is not the condition seen in *Bdellamaris*. There is also a marked difference in the external appearance of the two genera with *Trachelobdella* having a distinct trachelosome and wide urosome and a terminal caudal sucker, whereas *Bdellamaris* has a more fusiform body and a subterminal caudal sucker.

Although Richardson performed many studies in the waters surrounding New Zealand, the extent of sampling is not known. Many new species may exist and a thorough study of New Zealand's marine leech fauna is warranted.

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